Second Semester Examination
2018/2019 Academic Session

June 2019

EEU104 – Electrical Technology
(Teknologi Elektrik)

Duration : 3 hours
(Masa : 3 jam)

Please check that this examination paper consists of THIRTEEN (13) pages and FIVE (5) pages of printed appendix material before you begin the examination.

[Sila pastikan bahawa kertas peperiksaan ini mengandungi TIGA BELAS (13) muka surat dan LIMA (5) muka surat lampiran yang bercetak sebelum anda memulakan peperiksaan ini.]

Instructions: This question paper consists of **FOUR (4)** questions. Answer **ALL** questions. All questions carry the same marks.

[***Arahan:*** *Kertas soalan ini mengandungi **EMPAT (4)** soalan. Jawab **SEMUA** soalan. Semua soalan membawa jumlah markah yang sama.]*

In the event of any discrepancies, the English version shall be used.

[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah digunapakai.]

...2/-

1. (a) The voltage and current at the terminals of the circuit element are:

Voltan dan arus pada terminal elemen litar ialah:

$$v = i = 0 \qquad t < 0$$

$$\left.\begin{aligned} v &= e^{-500t} - e^{-1500t} V \\ i &= 30 - 40e^{-500t} + 10e^{-1500t} mA \end{aligned}\right\} \qquad t \geq 0$$

(i) Find the power at t = 1 ms.

Cari kuasa pada t = 1 ms.

(5 marks/*markah*)

(ii) How much energy is delivered to the circuit element between 0 and 1 ms?

Berapakah tenaga yang dihantar kepada elemen litar antara 0 and 1 ms?

(10 marks/*markah*)

(iii) Find the total energy delivered to the element.

Kira jumlah tenaga yang dihantar ke elemen tersebut.

(10 marks/*markah*)

…3/-

(b) For the circuit given in Figure 1.1, determine the currents, i_1 to i_5.

Bagi litar dalam Rajah 1.1, tentukan arus-arus, i_1 sehingga i_5.

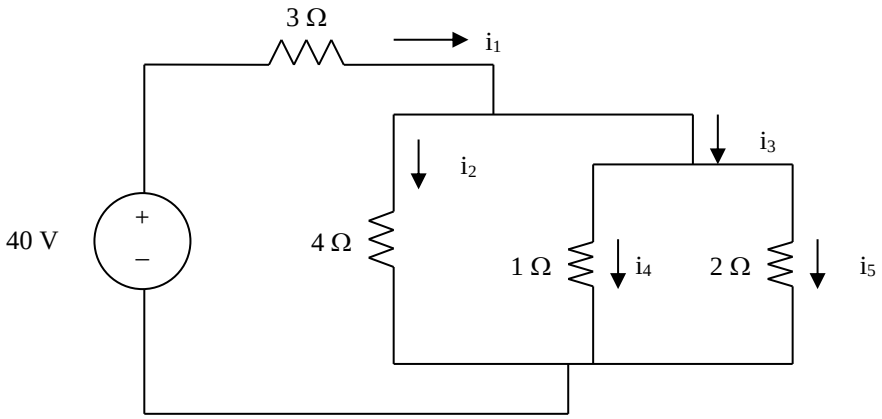

Figure 1.1

Rajah 1.1

(25 marks/*markah*)

(c) For the circuit shown in Figure 1.2, use the nodal analysis method to calculate:

Bagi litar dalam Rajah 1.2, gunakan kaedah analisis nodal untuk mencari:

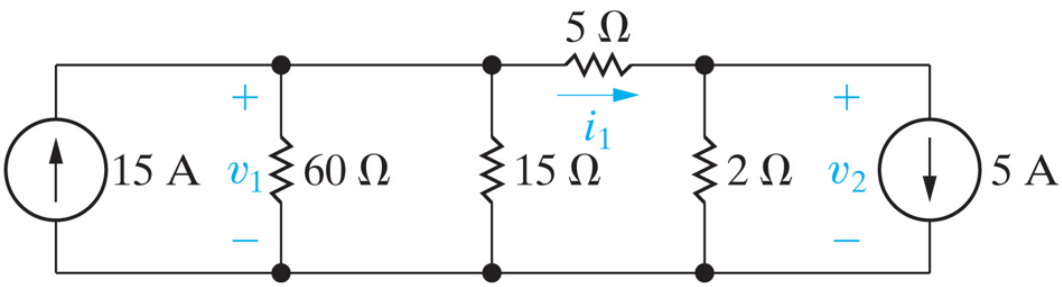

Figure 1.2

Rajah 1.2

(i) v_1, v_2, and i_1.

v_1, v_2, dan i_1.

(ii) Power delivered to the circuit by a 15-A source
Kuasa yang dihantar kepada litar dengan nilai 15 A.

(iii) Repeat (ii) for the 5-A source.
Ulangi (ii) pada punca bernilai 5 A.

(25 marks/*markah)*

(d) Find the mesh currents, i_1 and i_2 of the circuit in Figure 1.3.
Cari arus-arus gegelung, i_1 dan i_2 *bagi litar dalam Rajah 1.3.*

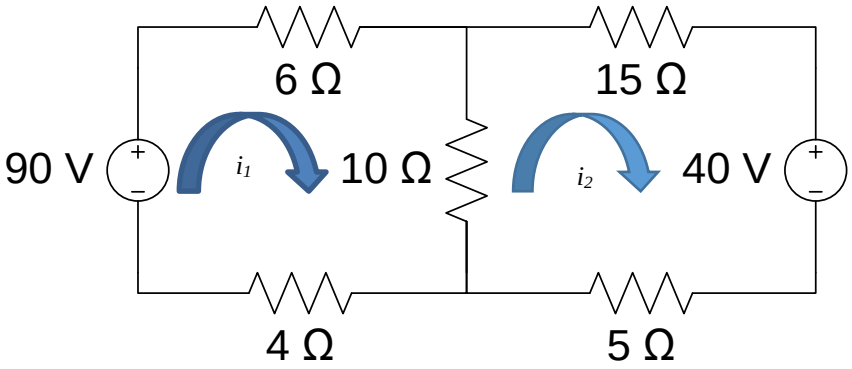

Figure 1.3
Rajah 1.3

(25 marks/*markah*)

2. (a) Consider the circuit given in Figure 2.1:

Pertimbangkan litar dalam Rajah 2.1:

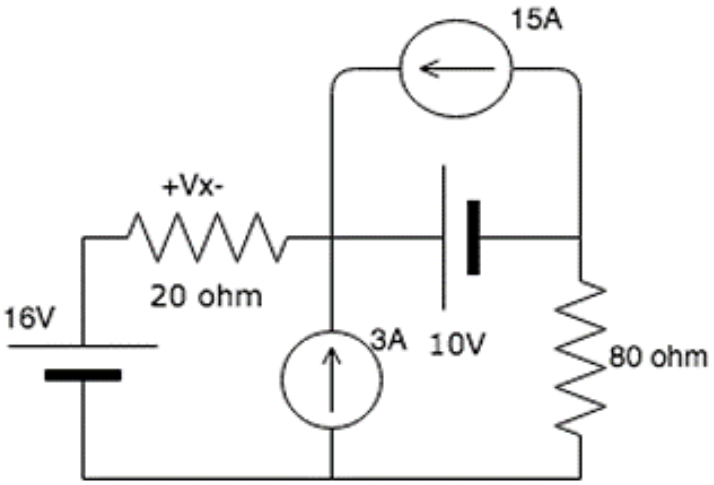

Figure 2.1
Rajah 2.1

(i) Find the value of Vx due to the 16-V source

Cari nilai Vx merujuk kepada sumber bernilai 16 V.

*(*10 marks/*markah*)

(ii) Find Vx due to the 3-A source.

Cari nilai Vx merujuk kepada sumber 3 A.

*(*10 marks/*markah*)

(iii) Find the value of Vx due to the 10-V source.

Cari nilai Vx merujuk kepada sumber 10 V.

(10 marks/*markah*)

(iv) Find the voltage due to the 15-A source.

Cari nilai Vx merujuk kepada sumber 15 A.

*(*10 marks/*markah*)

(b) Consider the circuit given in Figure 2.2.
Pertimbangkan litar diberi dalam Rajah 2.2.

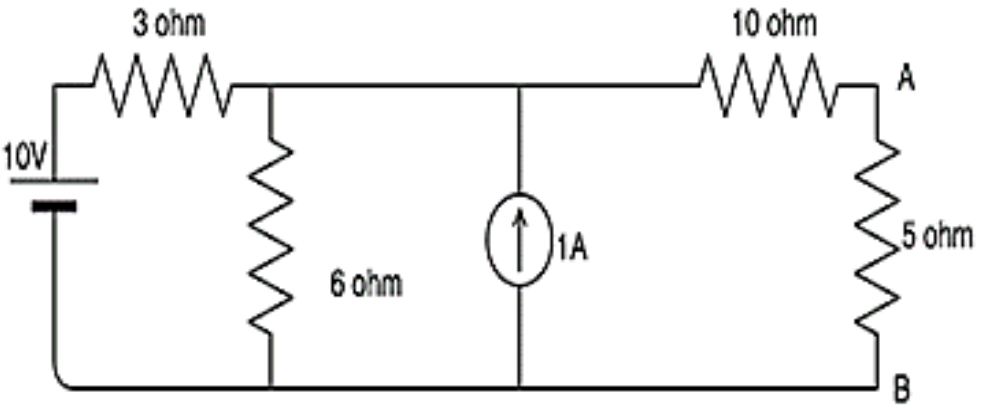

Figure 2.2
Rajah 2.2

(i) Calculate the Norton's equivalent voltage for the circuit if a 5-ohm load resistance is used.

Kira voltan setara Norton bagi litar tersebut jika beban rintangan bernilai 5 ohm digunakan.

*(*10 marks/*markah*)

(ii) Find the current in the 5-ohm resistance using Norton's theorem.
Cari nilai arus pada perintang 5 ohm menggunakan teorem Norton.

(15 marks/*markah*)

(iii) Which theorem is also known as the 'dual' of Norton's theorem?

Teorem manakah yang turut dikenali sebagai 'sepunya' bagi teorem Norton?

(5 marks/*markah*)

(c) (i) Consider these statements:
Pertimbangkan kenyataan ini:

Do you agree or disagree with the above sentence?
Adakah anda setuju atau tidak bersetuju dengan kenyataan di atas?

Capacitor tries to keep its current constant.
Kapasitor cuba mengekalkan arus yang malar.

Inductor tries to keep its voltage constant
Induktor cuba mengekalkan voltan yang setara

(10 marks/*markah*)

(ii) Consider Figure 2.3 as below:
Perhatikan Rajah 2.3 seperti di bawah:

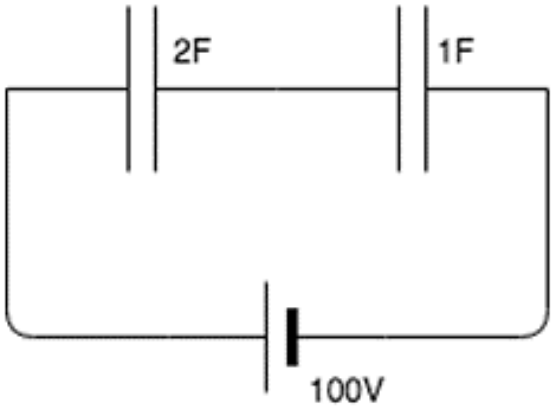

Figure 2.3
Rajah 2.3

Calculate the voltage across the 1F and 2F capacitors.
Kira voltan yang melalui kapasitor bernilai 1F dan 2F.

(20 marks/*markah*)

3. (a) The current of the input to the circuit shown in Figure 3.1, is given by:

Arus masukan kepada litar yang ditunjukkan di dalam Rajah 3.1 di berikan oleh:

$$i(t) = 3e^{-25t} \quad \text{A} \qquad \text{for t} > 0$$

The initial capacitor voltage is given by $v_c(0) = -2\,V$. Determine the current source voltage, $v(t)$, for $\text{t} > 0$.

Voltan kapasitor awal diberikan oleh $v_c(0) = -2\,V$. Tentukan voltan bagi sumber arus, v (t), untuk $t > 0$.

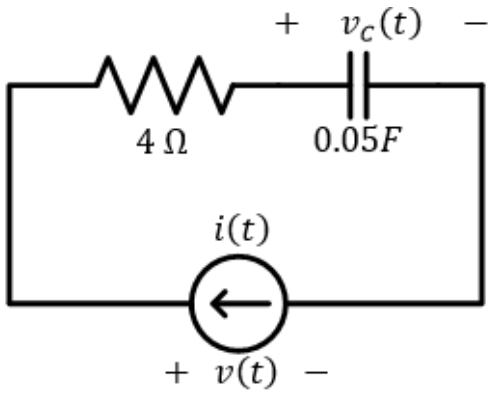

Figure 3.1
Rajah 3.1

(25 marks/*markah*)

(b) Determine the voltage across inductor, *v* in the circuit shown in Figure 3.2 for $\text{t} > 0$, using the exponential form.

Tentukan voltan pada induktor untuk $t > 0$. Gunakan bentuk eksponen.

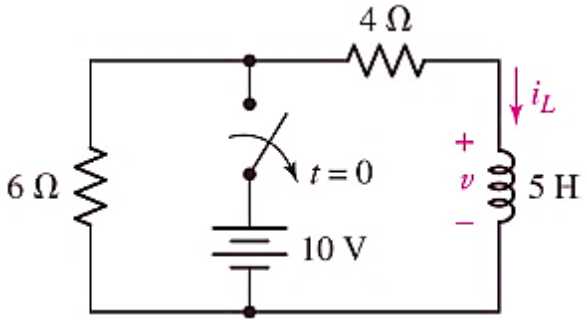

Figure 3.2
Rajah 3.2

(25 marks/*markah*)

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(c) Find the step response $v(t)$ and $i(t)$ to $v_s = 5\,u(t)$ V in the circuit shown in Figure 3.3.

Carikan tindakbalas langkah $v(t)$ dan $i(t)$ kepada $v_s = 5\,u(t)$ V dalam litar yang ditunjukkan dalam Rajah 3.3.

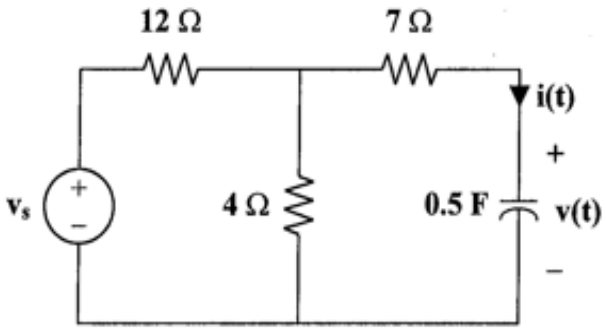


Figure 3.3
Rajah 3.3

(25 marks/*markah*)

(d) Determine i and v in the following circuit shown by Figure 3.4, using phasor approach.

Tentukan i dan v daripada litar berikut dalam Rajah 3.4 dengan menggunakan pendekatan pemfasa.

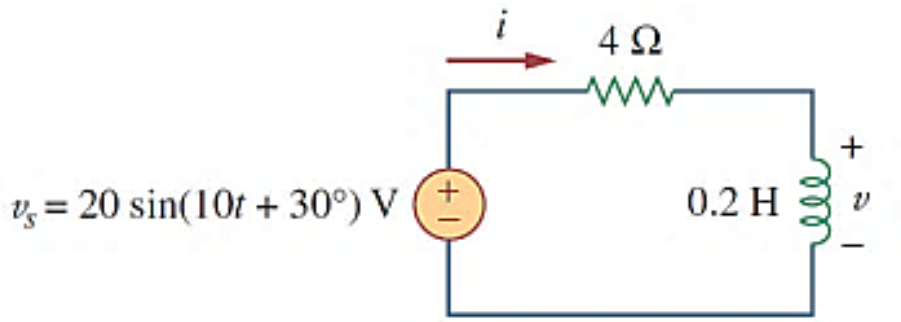
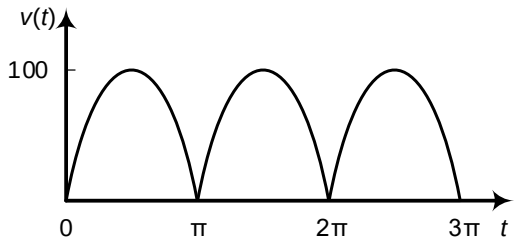


Figure 3.4
Rajah 3.4

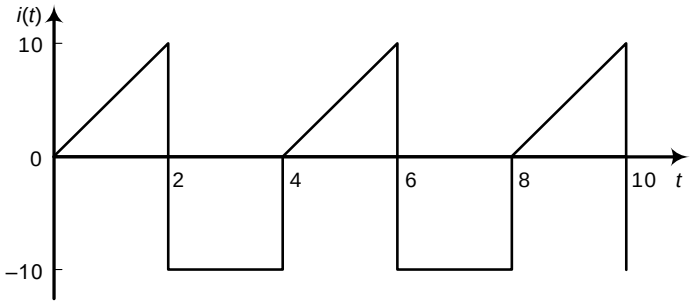
(25 marks/*markah*)

4. (a) Given the voltage and current waveforms in Figure 4.1 below,

Diberi bentuk gelombang bagi voltan dan arus di dalam Rajah 4.1 di bawah,



(a)



(b)

Figure 4.1
Rajah 4.1

(i) Calculate the root-mean-square voltage (V_{rms}) in the circuit given in Figure 4.1(a).

Kirakan nilai voltan punca min kuasa dua (V_{pmkd}) dalam litar yang diberikan dalam Rajah 4.1(b).

(10 marks/*markah*)

(ii) Calculate the root-mean-square current, I_{rms} for Figure 4.1(b)

Kirakan nilai arus punca min kuasa dua, I_{pmkd} untuk Rajah 4.1(b).

(10 marks/*markah*)

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(iii) Assuming the waveforms are originated from a voltage source (Figure 4.1(a)) and a current source (Figure 4.1(b)), respectively, calculate the average power dissipated through an 8Ω resistor connected to them.
Provide answer for each of the waveform.

Dengan mengandaikan setiap bentuk gelombang tersebut berasal daripada suatu sumber voltan (Rajah 4.1(a)) dan sumber arus (Rajah 4.1(b)), masing-masingnya, kirakan kuasa purata yang hilang di dalam suatu perintang 8Ω yang tersambung kepada sumber voltan dan arus tersebut.
Berikan jawapan untuk setiap bentuk gelombang tersebut.

(5 marks/*markah*)

(b) Determine the average power generated by each source (denoted by elements 1 and 5) and the average power absorbed by the remaining elements inside the circuit (denoted by elements 2 to 4) shown in Figure 4.2.
Include in the calculation any element (if any) that generates/absorbs no average power, i.e. 0W.

Dapatkan kuasa purata yang dijana oleh setiap sumber (ditunjukkan dengan elemen 1 dan 5) dan kuasa purata yang diserap oleh elemen-elemen lain (ditunjukkan dengan elemen 2 hingga 4) yang ditunjukkan dalam Rajah 4.2.
Kirakan juga (sekiranya ada) sebarang elemen yang tidak menjana/menyerap kuasa purata, i.e. 0W.

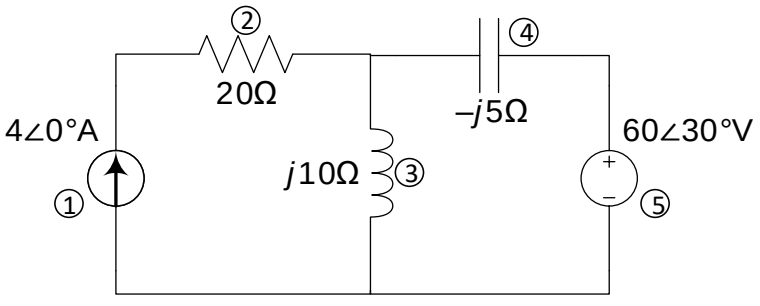

Figure 4.2
Rajah 4.2

(25 marks/*markah*)

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(c) Calculate the phasor currents, I_1 and I_2 in the circuit shown in Figure 4.3 below.

Kirakan arus pemfasa, I_1 dan I_2 dalam litar yang ditunjukkan dalam Rajah 4.3 di bawah.

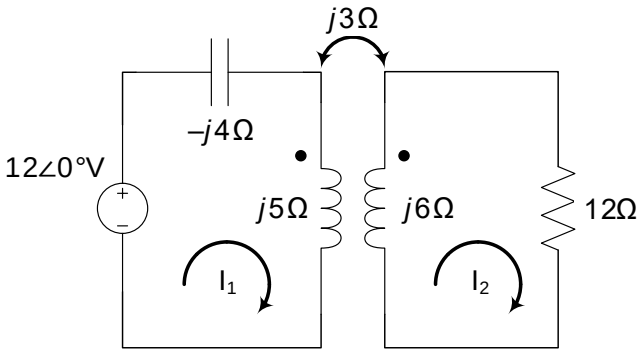

Figure 4.3
Rajah 4.3

(20 marks/*markah*)

(d) Calculate:

Kira:

(i) Line currents in the three-wire Y-Y system in Figure 4.4, and

Arus talian di dalam sistem tiga-wayar Y-Y dalam Rajah 4.4, dan

(10 marks/*markah*)

(ii) Line currents and phase currents in the Y-Δ transformation system in Figure 4.5.

Arus talian dan arus fasa dalam sistem transformasi Y-Δ dalam Rajah 4.5

(20 marks/*markah*)

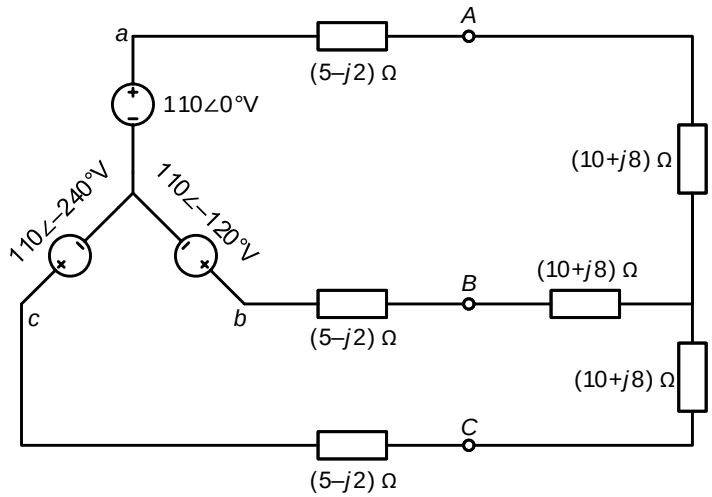

Figure 4.4
Rajah 4.4

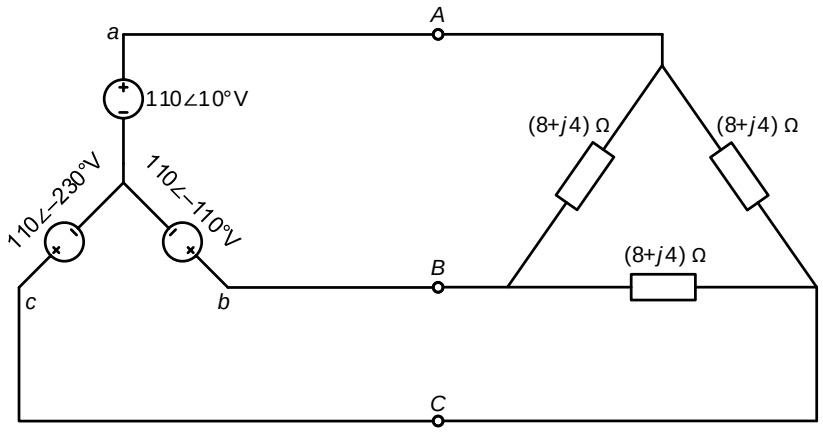

Figure 4.5
Rajah 4.5

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APPENDIX

LAMPIRAN

Mathematical Formulas

This appendix – by no means exhaustive – serves as a handy reference. It does contain all the formulas needed to solve circuit problems in this examination book.

Quadratic Formula

The roots of the quadratic equation $ax^2 + bx + c = 0$ are

$$x_1, x_2 = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Trigonometric Identities

$$\sin(-x) = -\sin x$$

$$\cos(-x) = \cos x$$

$$\sec x = \frac{1}{\cos x}, \csc x = \frac{1}{\sin x}$$

$$\tan x = \frac{\sin x}{\cos x}, \cot x = \frac{1}{\tan x}$$

$$\sin(x \pm 90°) = \pm \cos x$$

$$\cos(x \pm 90°) = \mp \sin x$$

$$\sin(x \pm 180°) = -\sin x$$

$$\cos(x \pm 180°) = -\cos x$$

$$\cos^2 x + \sin^2 x = 1$$

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C} \quad \text{(law of sines)}$$

$$a^2 = b^2 + c^2 - 2bc \cos A \quad \text{(law of cosines)}$$

$$\frac{\tan\frac{1}{2}(A - B)}{\tan\frac{1}{2}(A + B)} = \frac{a - b}{a + b} \quad \text{(law of tangents)}$$

$$\sin(x \pm y) = \sin x \cos y \pm \cos x \sin y$$

$$\cos(x \pm y) = \cos x \cos y \mp \sin x \sin y$$

$$\tan(x \pm y) = \frac{\tan x \pm \tan y}{1 \mp \tan x \tan y}$$

$$2 \sin x \sin y = \cos(x - y) - \cos(x + y)$$

$$2 \sin x \cos y = \sin(x + y) + \sin(x - y)$$

$$2 \cos x \cos y = \cos(x + y) + \cos(x - y)$$

$$\sin 2x = 2 \sin x \cos x$$

$$\cos 2x = \cos^2 x - \sin^2 x = 2 \cos^2 x - 1 = 1 - 2 \sin^2 x$$

$$\tan 2x = \frac{2\tan x}{1-\tan^2 x}$$

$$\sin^2 x = \frac{1}{2}(1-\cos 2x)$$

$$\cos^2 x = \frac{1}{2}(1+\cos 2x)$$

$$K_1\cos x + K_2 \sin x = \sqrt{K_1^2 + K_2^2}\cos\left(x + \tan^{-1} - \frac{K_2}{K_1}\right)$$

$$e^{\pm jx} = \cos x \pm j\sin x \quad \text{(Euler's identity)}$$

$$\cos x = \frac{e^{jx} + e^{-jx}}{2}$$

$$\sin x = \frac{e^{jx} - e^{-jx}}{2j}$$

$$1 \text{ rad} = 57.296°$$

Hyperbolic Functions

$$\sinh x = \frac{1}{2}(e^x - e^{-x})$$

$$\cosh x = \frac{1}{2}(e^x + e^{-x})$$

$$\tanh x = \frac{\sinh x}{\cosh x}$$

$$\coth x = \frac{1}{\tanh x}$$

$$\text{csch}\, x = \frac{1}{\sinh x}$$

$$\text{sech}\, x = \frac{1}{\cosh x}$$

$$\sinh(x \pm y) = \sinh x \cosh y \pm \cosh x \sinh y$$

$$\cosh(x \pm y) = \cosh x \cosh y \pm \sinh x \sinh y$$

Derivatives

If $U = U(x)$, $V = V(x)$, and $a =$ constant,

$$\frac{d}{dx}(aU) = a\frac{dU}{dx}$$

$$\frac{d}{dx}(UV) = U\frac{dV}{dx} + V\frac{dU}{dx}$$

$$\frac{d}{dx}\left(\frac{U}{V}\right) = \frac{\left(V\frac{dU}{dx} - U\frac{dV}{dx}\right)}{V^2}$$

$$\frac{d}{dx}(aU^n) = naU^{n-1}$$

$$\frac{d}{dx}(a^U) = a^U \ln a \frac{dU}{dx}$$

$$\frac{d}{dx}(e^U) = e^U \frac{dU}{dx}$$

$$\frac{d}{dx}(\sin U) = \cos U \frac{dU}{dx}$$

$$\frac{d}{dx}(\cos U) = -\sin U \frac{dU}{dx}$$

Indefinite Integrals

If $U = U(x)$, $V = V(x)$, and $a =$ constant,

$$\int a\,dx = ax + C$$

$$\int U\,dV = UV - \int V\,dU \quad \text{(integration by parts)}$$

$$\int U^n\,dU = \frac{U^{n+1}}{n+1} + C, \quad n \neq 1$$

$$\int \frac{dU}{U} = \ln U + C$$

$$\int a^U\,dU = \frac{a^U}{\ln a} + C, \quad a > 0, a \neq 1$$

$$\int e^{ax}\,dx = \frac{1}{a}e^{ax} + C$$

$$\int xe^{ax}\,dx = \frac{e^{ax}}{a^2}(ax - 1) + C$$

$$\int x^2e^{ax}\,dx = \frac{e^{ax}}{a^3}(a^2x^2 - 2ax + 2) + C$$

$$\int \ln x\,dx = x\ln x - x + C$$

$$\int \sin ax\,dx = -\frac{1}{a}\cos ax + C$$

$$\int \cos ax\,dx = \frac{1}{a}\sin ax + C$$

$$\int \sin^2 ax\,dx = \frac{x}{2} - \frac{\sin 2ax}{4a} + C$$

$$\int \cos^2 ax\,dx = \frac{x}{2} + \frac{\sin 2ax}{4a} + C$$

$$\int x\sin ax\,dx = \frac{1}{a^2}(\sin ax - ax\cos ax) + C$$

$$\int x\cos ax\,dx = \frac{1}{a^2}(\cos ax + ax\sin ax) + C$$

$$\int x^2 \sin ax\, dx = \frac{1}{a^3}(2ax \sin ax + 2\cos ax - a^2x^2 \cos ax) + C$$

$$\int x^2 \cos ax\, dx = \frac{1}{a^3}(2ax \cos ax - 2\sin ax + a^2x^2 \sin ax) + C$$

$$\int e^{ax} \sin bx\, dx = \frac{e^{ax}}{a^2 + b^2}(a \sin bx - b \cos bx) + C$$

$$\int e^{ax} \cos bx\, dx = \frac{e^{ax}}{a^2 + b^2}(a \cos bx + b \sin bx) + C$$

$$\int \sin ax \sin bx\, dx = \frac{\sin(a-b)x}{2(a-b)} - \frac{\sin(a+b)x}{2(a+b)} + C, \quad a^2 \neq b^2$$

$$\int \sin ax \cos bx\, dx = -\frac{\cos(a-b)x}{2(a-b)} - \frac{\cos(a+b)x}{2(a+b)} + C, \quad a^2 \neq b^2$$

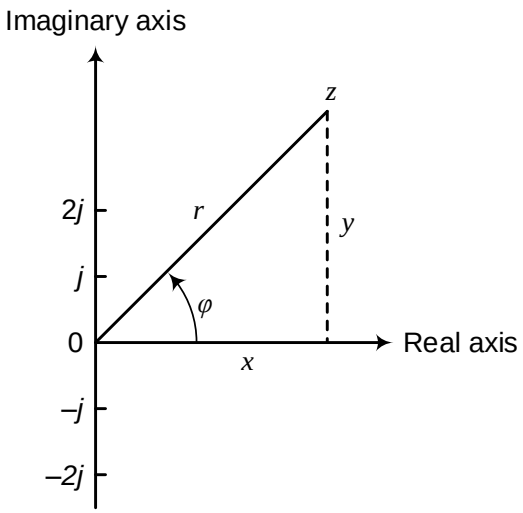
$$\int \cos ax \cos bx\, dx = \frac{\sin(a-b)x}{2(a-b)} + \frac{\sin(a+b)x}{2(a+b)} + C, \quad a^2 \neq b^2$$

$$\int \frac{dx}{a^2 + x^2} = \frac{1}{a}\tan^{-1}\frac{x}{a} + C$$

$$\int \frac{x^2 dx}{a^2 + x^2} = x - a\tan^{-1}\frac{x}{a} + C$$

$$\int \frac{dx}{(a^2 + x^2)^2} = \frac{1}{2a^2}\left(\frac{x}{x^2 + a^2} + \frac{1}{a}\tan^{-1}\frac{x}{a}\right) + C$$

Phasor & Complex Number



Complex number in rectangular form:

$$z = x + jy$$

$$r = \sqrt{x^2 + y^2}$$

$$\varphi = \tan^{-1}\frac{y}{x}$$

$$z = r(\cos\varphi + j\sin\varphi)$$

$$\frac{1}{j} = -j \text{ and } j = 1\angle 90°$$

Complex number in polar form:

$$z = r\angle\varphi$$

Complex number in exponential form:

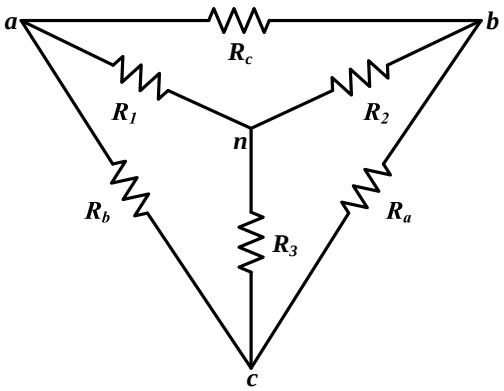
$$z = re^{j\varphi}$$

Sinusoid ↔ phasor transformation:

$$V_m \cos(\omega t + \varphi) \leftrightarrow V_m\angle\varphi$$
$$V_m \sin(\omega t + \varphi) \leftrightarrow V_m\angle(\varphi - 90°)$$
$$I_m \cos(\omega t + \theta) \leftrightarrow I_m\angle\theta$$
$$I_m \sin(\omega t + \theta) \leftrightarrow I_m\angle(\theta - 90°)$$

Mathematic operation of complex number:

Addition	$z_1 + z_2 = (x_1 + x_2) + j(y_1 + y_2)$
Subtraction	$z_1 - z_2 = (x_1 - x_2) + j(y_1 - y_2)$
Multiplication	$z_1 z_2 = r_1 r_2\angle(\varphi_1 + \varphi_2)$
Division	$\frac{z_1}{z_2} = \frac{r_1}{r_2}\angle(\varphi_1 - \varphi_2)$
Reciprocal	$\frac{1}{z} = \frac{1}{r}\angle -\varphi$
Square-root	$\sqrt{z} = \sqrt{r}\angle(\varphi/2)$
Complex conjugate	$z^* = x - jy = r\angle -\varphi = re^{-j\varphi}$



$$R_1 = \frac{R_b R_c}{R_a + R_b + R_c} \quad R_a = \frac{R_1 R_2 + R_2 R_3 + R_3 R_1}{R_1}$$
$$R_2 = \frac{R_c R_a}{R_a + R_b + R_c} \quad R_b = \frac{R_1 R_2 + R_2 R_3 + R_3 R_1}{R_2}$$
$$R_3 = \frac{R_a R_b}{R_a + R_b + R_c} \quad R_c = \frac{R_1 R_2 + R_2 R_3 + R_3 R_1}{R_3}$$